Claims

[c1] 1. A method for operating a vehicle having a first electrical bus for providing power to accessory loads and a second electrical bus electrically coupled to the first electrical bus, the second electrical bus including an ultracapacitor and at least one electric motor/generator for providing electric motor traction assist to wheels of the vehicle, the method comprising:
providing electric motor assist by powering the electric motor/generator with energy from the ultracapacitor; and
regulating a voltage of the first electrical bus within a predefined voltage range while the electric motor provides the electric motor traction assist.

[c2] 2. The method of claim 1, wherein regulating the voltage of the first electrical bus includes executing a start-up energy management mode.

[c3] 3. The method of claim 1, wherein regulating the voltage of the first electrical bus includes executing an electric traction assist energy management mode.

[c4] 4. The method of claim 1, wherein regulating the voltage

of the first electrical bus includes executing a running energy management mode.

[c5] 5. The method of claim 1, wherein regulating the first electrical bus within the predefined voltage range includes controlling a DC/DC converter electrically coupled between the first and second electrical buses to prevent electric energy to flow from the second to the first bus during the electric motor traction assist.

[c6] 6. The method of claim 5, further comprising providing energy from the first to the second electrical bus if an ultracapacitor voltage of the ultracapacitor is below a predefined voltage limit by controlling the DC/DC converter such that electric energy flows from the first to the second electric bus while still regulating the first electric bus within the predefined voltage range, the electric motor traction assist provided based on the electric energy flow from the first to the second electric bus.

[c7] 7. The method of claim 6, further comprising permitting energy to flow from a battery electrically coupled to the first electrical bus to the second electrical bus to permit the electric energy to flow from the first to the second electric bus.

[c8] 8. The method of claim 7, further comprising controlling

an alternator set-point to increase energy flow to the first electrical bus from an alternator electrically coupled to the first electrical bus based on the energy flow from the battery to the second electric bus if the battery voltage of the battery is below a predefined battery voltage range.

[c9] 9. The method of claim 6, further comprising regeneratively braking the electric motor/generator for charging the ultracapacitor and for providing energy to the first electrical bus by regulating the flow of energy from the second to the first electrical bus while still regulating the first electric bus within the predefined voltage range by controlling energy flow through the DC/DC converter.

[c10] 10. The method of claim 9, further comprising lowering an alternator set-point based on the energy flow produced by the regenerative braking to limit energy provided by the alternator to the first electrical bus for regulating the first electric bus within the predefined voltage range.

[c11] 11. A vehicle electrical distribution system, comprising:
a first electrical bus for providing power to accessory loads and
a second electrical bus electrically coupled to the first electrical bus, the second electrical bus including an ul-

tracapacitor and at least one electric motor/generator for providing electric motor traction assist to wheels of the vehicle; and

an electronic control module to control electrical energy flow between the first and second electrical buses for providing electric motor traction assist by powering the electric motor/generator with energy from the ultracapacitor and regulating a voltage of the first electrical bus within a predefined voltage range while the electric motor provides the electric motor traction assist.

[c12] 12. The system of claim 11, wherein the electronic control module communicates with a DC/DC converter coupled between the first and second electrical buses to control electrical energy flow between the first and second electrical buses, the control of the DC/DC converter sufficient for regulating the first electrical bus within the predefined voltage range while the electric motor provides the electric motor traction assist.

[c13] 13. An electric distribution system for use in a hybrid electric vehicle (HEV), the system comprising:

an electric motor/generator to provide torque for use in electric assist and to provide electric energy from regenerative braking;

an ultracapacitor to store and release electric energy;

an electric assist bus to electrically couple the electric

motor/generator to the ultracapacitor to permit electric energy to flow therebetween;
an alternator to provide electric energy;
an accessory load;
a battery to store and release electrically energy;
an accessory load bus to electric couple the alternator to the accessory load and the battery to permit electric energy to flow therebetween;
a DC/DC converter to electrically couple the electric assist bus to the accessory load bus to permit electric energy to flow throughout the system; and
an energy management controller to stabilize the accessory load bus within a predefined accessory load bus voltage range by controlling electric energy flow through the DC/DC converter, electric energy consumption and production of the electric motor/generator, and electric energy production of the alternator.

[c14] 14. The system of claim 13, wherein the energy management controller maintains the accessory load bus voltage within the predefined accessory load bus voltage range during electric assist by one of (i) controlling the DC/DC converter to prevent electric energy to flow between the electric assist bus and the accessory load bus if an ultracapacitor voltage is greater than or within a predefined ultracapacitor voltage range, (ii) controlling the DC/DC

converter to permit electric energy to flow from the battery through the accessory load bus to the electric assist bus if the ultracapacitor voltage is less than the predefined ultracapacitor voltage range, or (ii) controlling an alternator set-point to increase energy flow to the accessory load bus if a battery voltage of the battery is less than a predefined battery voltage range and the ultracapacitor voltage is less than the predefined ultracapacitor voltage range.

[c15] 15. The system of claim 13, wherein the energy management controller maintains the accessory load bus voltage within the predefined accessory load bus voltage range during regenerative braking mode by controlling an alternator set-point to stop transferring electric energy to the accessory load bus and one of (i) controlling the DC/DC converter to prevent electric energy to flow from the electric assist bus to the accessory load bus, (ii) controlling the DC/DC converter to permit electric energy to flow from the electric assist bus to the accessory load bus to charge the battery by setting a DC/DC converter voltage to a first DC/DC converter voltage, or (iii) controlling the DC/DC converter to permit electric energy to flow from the electric assist bus to the accessory load bus to charge the battery and to power the accessory load by setting a DC/DC converter voltage to a second

DC/DC converter voltage, wherein the first DC/DC converter voltage is less than the second DC/DC voltage.

[c16] 16. The system of claim 13, wherein the energy management controller maintains the accessory load bus voltage within the predefined accessory load bus voltage range during running mode by setting a battery state of charge for the battery, wherein setting the battery state of charge includes (i) lowering a set-point of the alternator to decrease the battery state of charge if the battery state of charge is greater than a predefined battery state of charge range, (ii) raising the set-point of the alternator to increase the battery state of charge if the battery state of charge is less than the predefined battery state of charge range, and (iii) maintaining the set-point of the alternator if the battery state of charge is within the predefined battery state of charge range.

[c17] 17. The system of claim 16, wherein maintaining the accessory load bus voltage within the predefined accessory load bus voltage range during running mode further includes setting an ultracapacitor voltage after setting the battery state of charge, wherein setting the ultracapacitor voltage includes one of (i) checking a speed of the HEV and controlling the DC/DC converter to permit electric energy to flow from the accessory load bus to the electric assist bus to increase the ultracapacitor voltage

if the ultracapacitor voltage is less than a predefined ultracapacitor voltage range and the HEV speed is less than a predefined vehicle speed range, (ii) checking the speed of the HEV and maintaining the ultracapacitor voltage if the ultracapacitor voltage is less than the predefined ultracapacitor voltage range and the HEV speed is greater than the predefined vehicle speed range, (iii) maintaining the ultracapacitor voltage if the ultracapacitor voltage is within the predefined ultracapacitor voltage range, (iv) checking the speed of the HEV and controlling the DC/DC converter to permit electric energy to flow from the electric assist bus to the accessory load bus to decrease the ultracapacitor voltage if the ultracapacitor voltage is greater than the predefined ultracapacitor voltage range and the HEV speed is greater than the predefined vehicle speed range, and (v) checking the speed of the HEV and maintaining the ultracapacitor voltage if the ultracapacitor voltage is greater than the predefined ultracapacitor voltage range and the HEV speed is less than the predefined vehicle speed range.

[c18] 18. The system of claim 13, wherein the energy management controller establishes the accessory load bus voltage within the predefined accessory load bus voltage range during vehicle start-up mode operation to enable electric traction assist, wherein establishing the acces-

sory load bus voltage includes (i) setting a battery voltage of the battery and subsequently (ii) setting an ultracapacitor voltage of the ultracapacitor.

[c19] 19. The system of claim 18, wherein setting the battery voltage includes (i) checking the battery state of charge and increasing a set-point of the alternator to increase the battery state of charge if the battery state of charge is less than a predefined battery state of charge range, (ii) checking the battery state of charge and decreasing the set-point of the alternator to decrease the battery state of charge if the battery state of charge is greater than the predefined battery state of charge range and the ultracapacitor voltage is greater than a predefined ultracapacitor voltage range, (iii) checking the battery state of charge and controlling the DC/DC converter to permit electric energy to flow from the accessory load bus to the electric assist bus to decrease the state of charge of the battery if the battery state of charge is greater than the predefined battery state of charge range and the ultracapacitor voltage is less than or within the predefined ultracapacitor voltage range, and (iv) maintaining the battery state of charge if the battery state of charge is within the predefined battery state of charge range.

[c20] The system of claim 19, wherein setting the ultracapacitor voltage includes (i) checking a ultracapacitor voltage and increasing the set-point of the alternator and controlling the DC/DC converter to permit electric energy to flow from the accessory load bus to the electric assist bus to increase the ultracapacitor voltage if the ultracapacitor voltage is less than the predefined ultracapacitor voltage range, or (ii) maintaining the ultracapacitor voltage if the ultracapacitor voltage is within or greater than the predefined ultracapacitor voltage range.